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ONR ltr, 14 Dec 1973

GENERAL ELECTRIC
COMPANY

MISSILE AND
SPACE DIVISION

SPACE SCIENCES
LABORATORY

PACE TECHNOLOGY CENTER (MAIL P. O. BOX 8555, PHILA. 1, PA.) . . . TEL. 969-2000

April 9, 1963

JBJECT: Contract Nonr-3867(00)
Quarterly Report No. 3

The enclosed quarterly letter report on the subject contract is sent to you in accordance with the distribution list furnished by Power Branch, Office of Naval Research, Department of the Navy.

Very truly yours,

J. H. Wood

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Space Sciences Laboratory

JHW/eb

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RESEARCH IN MHD POWER GENERATION

QUARTERLY REPORT NO. 3
(Period Ending March 30, 1963)

Contract: Nonr-3867(00)
Project Code 9800
Contract Date: 28 June, 1962

15 June 1962 - 30 June 1963
ARPA Order 325-326
Amount of Contract:$318,919

Project Scientist: Dr. G. W. Sutton
Telephone: 215-969-2674

Contractor: Space Sciences Laboratory
General Electric Company
P. O. Box 8555
Philadelphia 1, Penna.

INTRODUCTION

This program is directed toward the development of non-thermal and metastable ionization for closed cycle MHD electrical power generation systems with either metal vapors or seeded gases for naval applications. The program shall first, demonstrate non-thermal and metastable ionization, and second, generate actual power with such ionization. The cognizant scientist for ONR is Mr. Jack Satkowski, Power Branch, and for ARPA is Dr. John Huth.

SIGNIFICANT ACCOMPLISHMENTS

1. Work on the General Electric "Race Track" closed cycle experiment was terminated, as described by letter. This experiment had yielded some promising results on the MHD compressor, but had suffered from cracks and breakdowns of the MHD test sections. At the time of termination, new test sections were under construction.

2. Work on the cycles and systems analysis was terminated, except for a brief re-examination of the ejector-gas cycle. The model previously used and reported in the semi-annual report has been revised, and a report concerning the revised model is in preparation.

3. The barium diode experiment is now in operation again, following construction of a new and improved furnace.

4. Power generation has been achieved in the M-2 shock tube, using Xenon. Initially, about 0.5 amp per electrode was observed. With a slight increase in pressure, the current per electrode increased to 10 to 20 amps per electrode with a 2 ohm resistor.

With the electrodes short-circuited, the electrode current has risen to 200 to 400 amperes. To obtain the absolute gas conductivity, the electrode sheath resistance must be determined, and the Lin coil must be calibrated; both are planned for the next period. Preliminary evaluation of the data indicates that magnetically induced ionization has been achieved The cinespectrograph is presently being calibrated. This will be used in the next quarter to determine the electron temperature.

BARIUM-ARGON HEATED DIODE

A second carbon tube furnace has been constructed and is in operating condition. Several modifications have been incorporated into the design of this second furnace namely: (1) larger window apertures so that the overall f number of the system is approximately f-10; (2) replacement of outer water jackets with copper tubing, thus reducing appreciably the cost of the furnace; (3) replacement of mercury monometers with Bourdon type gauges - thereby keeping mercury vapor out of the system. With our present power supply, temperatures as high as 2000°C can be maintained. This temperature is quite adequate for our present purposes.

Several attempts were made to use alumina in the construction of the barium diode. In every case the barium appeared to soak into the alumina to such a degree that shorting through the alumina end pieces resulted. Clouds of haze, presumably due to the presence of barium oxides, also made spectroscopic measurements impossible. For these reasons alumina was abandoned as a diode construction material. We have resumed the use of boron nitride in the construction of the diodes and have made several more non-thermal ionization measurements. It was noticed that during the course of an experiment, the electrode spacing in the diode can change considerably and therefore, we have modified the diode design so that movement of the electrodes during heating is minimized. We are currently using this modified diode. It is anticipated that this modification will eliminate to a large extent the non-reproducibility of the barium data. Tests are currently in progress.

Future Plans:

1) Obtain reproducible data on non-thermal ionization of barium.

2) Observe electronic temperatures of the barium atom and ion.

3) Study alkali metal system.

SHOCK TUBE EXPERIMENTS

The most significant progress made during the last quarter was the conclusive experimental verification of the existence of non-equilibrium ionization in a magnetic field using a segmented electrode MHD channel. The basis for this claim is that the gas conductivity was measured downstream of the MHD test section with and without the magnetic field. It was observed that as the magnetic field was increased the conductivity increased. In addition to measuring the conductivity, the current flow in four of the sixteen electrodes was measured as was the Hall voltage in the flow direction. All these measurements are essentially in agreement with each other.

In addition a great deal of time was devoted to improving the diagnostic techniques used on the shock tube. These include the heat transfer gauges for velocity and temperature measurement, ionization gauges for velocity measurement, photomultipliers for velocity and luminosity measurements and for triggering.

During the last quarter the General Electric Company continued the fine facilities support that this experiment has received since its inception. An Ebert monochrometer was acquired with all its necesary accessories. The use of this monochrometer will be described later. Two additional Tektronix Dual Beam oscilloscopes were acquired bringing the total to five Tektronix Dual Beam Oscilloscopes (or the equivalent of ten single oscilloscopes). Without this large number of oscilloscopes, it would have taken as least three more months to collect the experimental data we now have. The reason for this is that after a given number of shocks the test section must be replaced. This is a very time consuming process. In addition, plans are being made to acquire more capacitors to enable us to reach 50,000 gauss magnetic field.

The rotating drum spectrograph which was built by the Spectroscopy group of the General Electric Space Sciences Laboratory was completed and installed near the shock tube. With the spectrograph time-resolved spectra can be obtained. The time resolution is 2 microseconds and the space resolution is 0.5 angstroms. With this one can obtain very accurate data of the rateof increaseof magnetic ionization and of the electron temperature.

A mass spectrometer residual gas analyzer has been brough with G. E. facilities funds and will be installed shortly on the shock tube. The purpose for using this instrument is to determine the effect of impurities on the magnetically induced ionization.

Finally the shock tube was instrumented for easier and more automatic operation.

It should be pointed out that the reason a great deal of data was accumulated in the last quarter was due to careful but lengthy preparation of the shock tube last year. During the next quarter, calibration of the Lin coil and sheath resistance will be made, and cinespectrographic measurements of the Xenon excitation will be made. Correlation with the theory of electron heating will also be made.

SHOCK TUBE RESULTS — XENON

V = 1040 M/SEC., p = 0.95 ATM.